Efficient Simulation of Snowflake Growth for Remote Sensing

NASA computer scientists have implemented a realistic model of snowflake growth to help researchers predict, with higher accuracy, the quantities of ice crystals and falling snow in the atmosphere. Ultimately, this work could lead to improved weather forecasts when the ice and snow contents of real clouds are more accurately derived from signals observed by instruments.

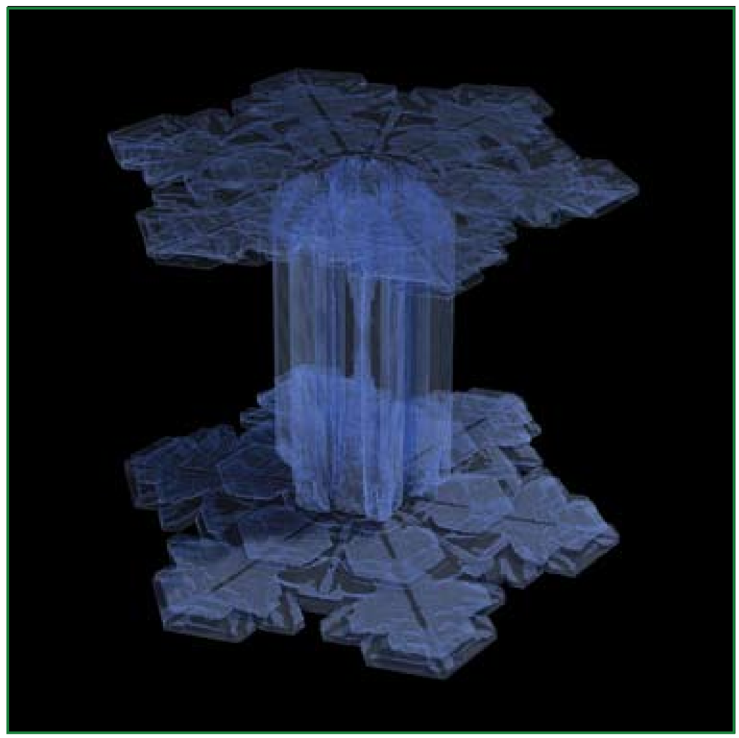
Without adequate characterization of the single-scattering properties for the particles being retrieved, accurate capture of their properties (such as mass and size) is not possible. Due to the symmetry of their spherical shape, we are able to characterize with high accuracy the single-scattering properties involving cloud droplets. Such is not the case, however, for non-spherical particles such as ice and snow crystals, which potentially require a much higher number of parameters to adequately describe their scattering properties.

The goal of this project is to find a small set of parameters that can adequately characterize single-scattering properties for ensembles of these non-spherical ice crystals. The "Snowfake" model (Gravner and Griffeath 2009), a numerical growth model for ice crystals based on vapor diffusion and deposition, is used to "grow" realistic ice crystals with the exquisitely fine features observed in nature. Single-scattering characterization based on these realistic crystals grown by Snowfake provides a better alternative to that obtained from simple geometric shapes, such as hexagonal columns or plates.

The Snowfake crystals and their corresponding single-scattering properties will be catalogued and stored in a database managed by an open-source relational database management system. This database will eventually be made publicly accessible through a web interface. Any scientist interested in the subject will be able to make use of the simulations done with Snowfake.

We have used the Test-Driven Development technique to rapidly create an optimized Message Passing Interface (MPI) implementation of the Snowfake model, which reduces the time to grow a single, high-resolution crystal from approximately one month to about an hour.

Creating a sufficiently diverse set of representative snow crystals would have taken years without NASA supercomputing resources—we can now populate our database in weeks.



Changing physical conditions can be represented by changing parameter values in the middle of a simulation. Here, the conditions initially favor vertical column-like growth of a snowflake, but later favor horizontal growth at the boundaries.

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